

The health impacts of coal power plants located in Shandong, Shanxi and Inner Mongolia

Summary

Shandong, Inner Mongolia and Shanxi rank as the top three coal consuming provinces in mainland China. In 2011, these three provinces together consumed 31% of the national total coal consumption, or 1.07 billion tons¹, which is approximately the same amount of coal used in the U.S for that same year. And emissions of three major air pollutants - SO₂, NO_x and soot - were respectively 20.9%, 18.71% and 20.75% of the national total². These pollutants are a major source of primary and secondary PM_{2.5}.

Data has revealed that in the first quarter of 2013, PM_{2.5} concentration levels of Jinan, Yantai city in Shandong province, and Taiyuan city in Shanxi province were more than two times the national standard, at 35 micrograms per cubic meter. PM_{2.5} concentration levels of Jinan city in the first quarter reached 159 micrograms per cubic meter, which is 4.5 times the national standard.³

Negotiations are currently underway in six provinces surrounding Beijing to sign an air pollution control liability statement with the central government. In June, Greenpeace released modeling results of an investigation into health impacts from coal power plants in Beijing, Tianjin and Hebei. Now we are expanding this work by releasing data for Shandong, Shanxi and Inner Mongolia. Greenpeace has commissioned U.S. air pollution modeling expert Dr. H. Andrew Gray to assess contributions made by coal-fired power plants to PM_{2.5} pollution in China. The modeling covers over 2,000 power plants, out of which 637 are located in Shandong, Shanxi and Inner Mongolia. Of these, 387 plants are in Shandong, 121 plants in Shanxi, and 129 plants in Inner Mongolia. The key findings are as follows:

- These three top coal consuming provinces caused an estimated 83,500 preliminary deaths in mainland China, with 29,800 deaths caused by coal power

1 <China Energy Statistical Yearbook 2012>, more details in appendix 3.

2 National Bureau of Statistics, <China Statistical Yearbook on Environment 2012>

3 Boyuan Foundation, <China: Big Bang policy changes needed to reduce PM_{2.5} concentration to 30>

plants in Shandong, 26,200 caused by coal power plants in Shanxi and 27,500 caused by coal power plants in Inner Mongolia.

- Other health impacts attributable to coal power plants within these three provinces include 108,400 children suffering from asthma, 140,500 cases of chronic bronchitis and 2,210 infant deaths.
- Coal power plants in Shandong caused an estimated 7,200 premature deaths, Shanxi's plants caused an estimated 2,800 premature deaths, and Inner Mongolian plants caused an estimated 1,500 premature deaths, within their respective regions.

The power sector consumes more than one third of all coal used in these three provinces⁴. Thus, if all coal-burning sectors were included in the impact estimates, the results would be even greater. This further emphasizes the urgent need for coal consumption control in these top three coal-consuming provinces.

Figure : The percentage of coal consumed in the power sectors of Shandong, Shanxi and Inner Mongolia.

Policy demand:

- Pollution from these top coal-consuming provinces must be curbed in order to reduce air pollution, and protect public health. These three provinces should commit to publishing a coal-burning reduction target and action plans.

4 <China Energy Statistical Yearbook 2012>, more details in appendix 3

Estimated health impacts

Table : Estimated health impacts caused by power plants in Shandong, Shanxi and Inner Mongolia provinces of mainland China.

	Shandong	Shanxi	Inner Mongolia	Total
Total mortality	29,800	26,200	27,500	83,500
<i>Mortality types:</i>				
<i>Stroke</i>	<i>16,800</i>	<i>14,700</i>	<i>15,300</i>	<i>46,800</i>
<i>Lung cancer</i>	<i>3,000</i>	<i>2,600</i>	<i>2,700</i>	<i>8,300</i>
<i>COPD</i>	<i>3,400</i>	<i>3,000</i>	<i>3,100</i>	<i>9,500</i>
<i>Ischemic heart disease</i>	<i>6,700</i>	<i>5,900</i>	<i>6,400</i>	<i>19,000</i>
<i>Infant mortality</i>	<i>820</i>	<i>700</i>	<i>690</i>	<i>2,210</i>
Asthma (children)	40,200	34,300	33,900	108,400
Asthma (adults)	7,700	6,500	6,500	20,700
Chronic Bronchitis	52,100	44,500	43,900	140,500

Table : Estimated health impacts caused by Shandong, Shanxi and Inner Mongolia power plants within their own province.

	Shandong	Shanxi	Inner Mongolia
Total mortality	7,200	2,800	1,500
<i>Mortality types:</i>			

<i>Stroke</i>	<i>4,000</i>	<i>1,600</i>	<i>810</i>
<i>Lung cancer</i>	<i>740</i>	<i>260</i>	<i>130</i>
<i>COPD</i>	<i>840</i>	<i>300</i>	<i>160</i>
<i>Ischemic heart disease</i>	<i>1,600</i>	<i>620</i>	<i>420</i>
<i>Infant mortality</i>	<i>220</i>	<i>60</i>	<i>30</i>
Asthma (children)	10,600	3,000	1,200
Asthma (adults)	2,000	580	240
Chronic Bronchitis	13,800	3,900	1,600

Maps modeling coal-fired power plants and air pollution

dispersion in Shandong, Shanxi and Inner Mongolia

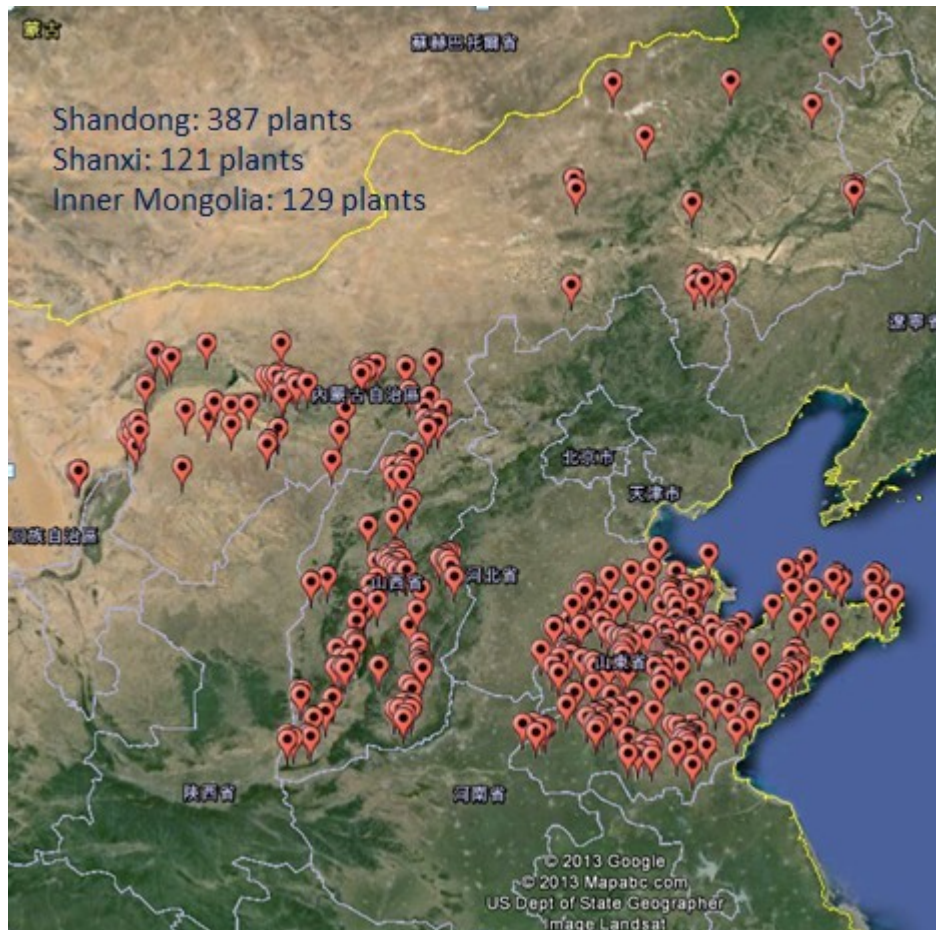


Figure : Map modeling coal-fired power plants in Shandong, Shanxi and Inner Mongolia.

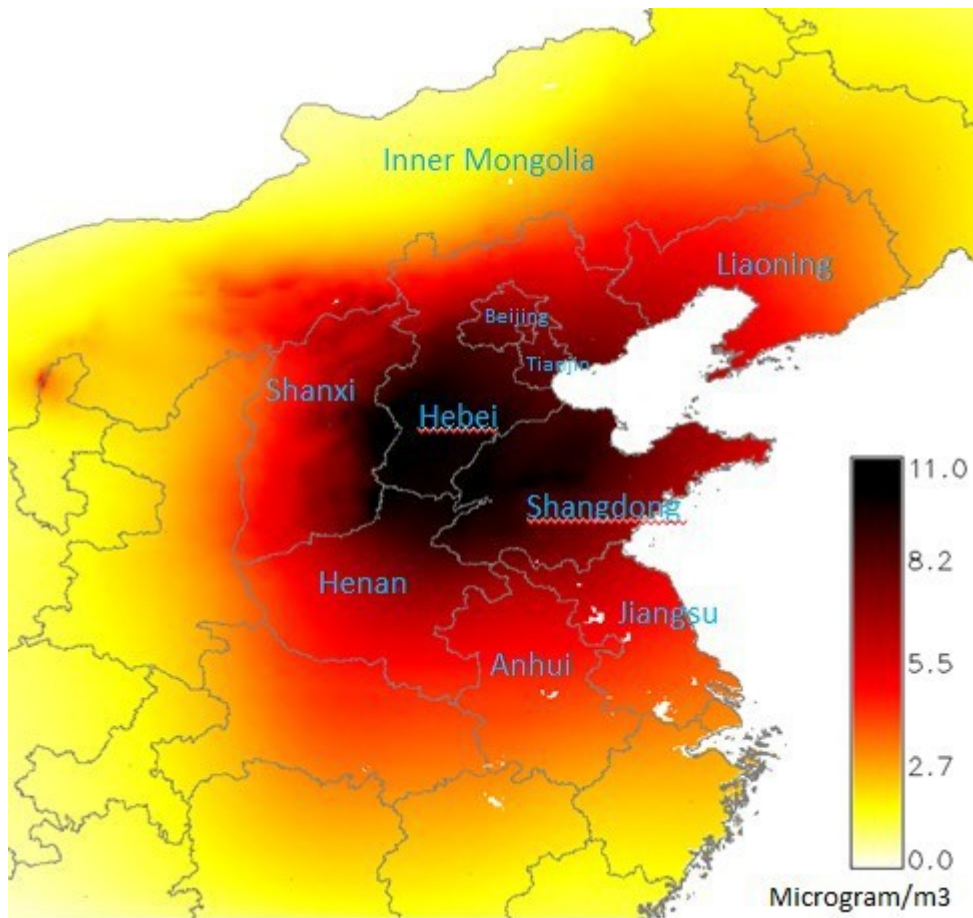


Figure : Estimated PM_{2.5} concentration increase attributed to coal power plants in Shandong, Shanxi and Inner Mongolia.

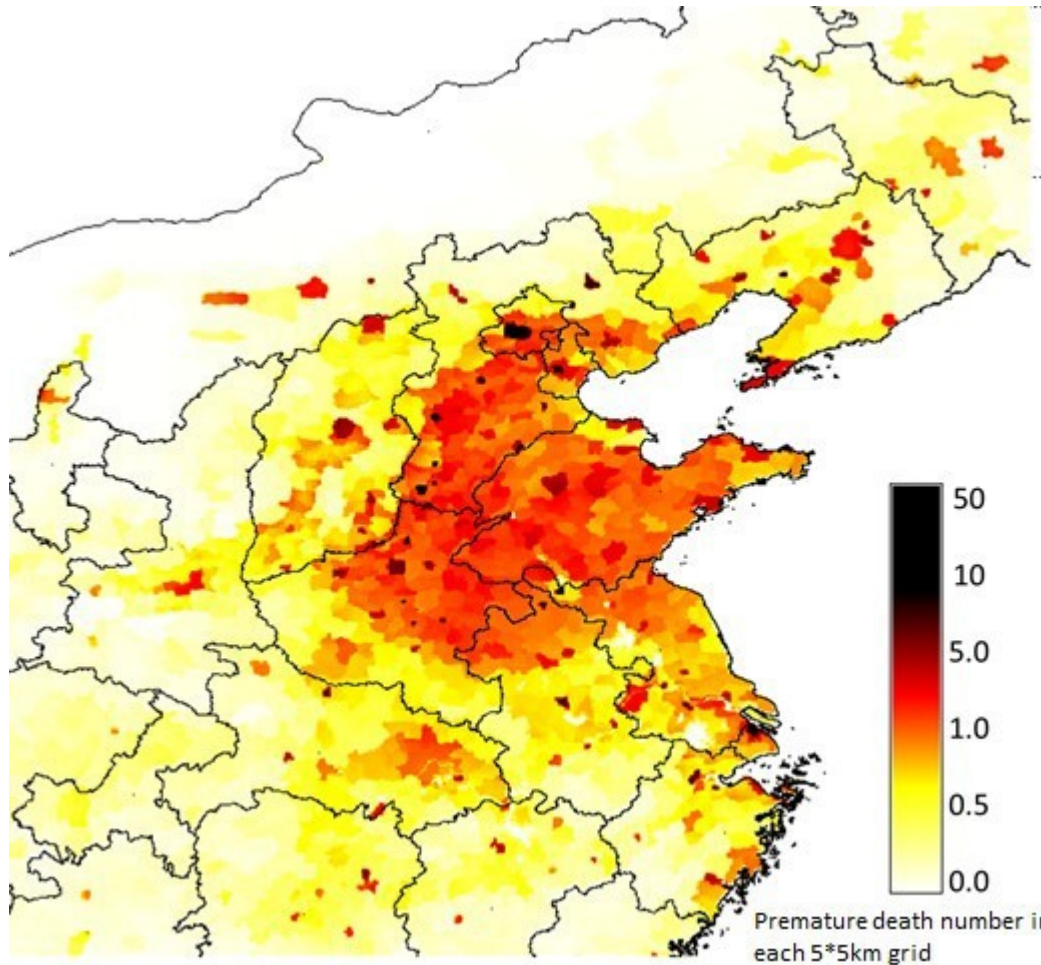


Figure : Estimated premature deaths attributed to coal power plants in Shandong, Shanxi and Inner Mongolia. Each grid cell represents a 5km x 5km region.

Appendix 1: Methodology

Greenpeace commissioned U.S. air pollution modeling expert Dr. Andrew Gray to assess the PM_{2.5} exposure caused by Chinese coal-fired power plants. Dr. Gray has 30 years of experience in air pollution research, having worked for the U.S. government, in academic projects and as an independent consultant. Dr. Gray used the CALPUFF modeling system to evaluate the dispersion of pollutants from over 2,000 operating coal-fired power plants, and the contribution these emissions make to PM_{2.5} levels in China.

The CALPUFF modeling system is recommended by the U.S. EPA for modeling long-range transport of air pollution from point sources, such as power plant stacks. It is an

advanced air pollution dispersion model that simulates the effects of 'time and space'-varying meteorological conditions on pollutant transport, transformation and removal.⁵ The model has been previously used in China by a Chinese-U.S. team in Harvard University⁶.

A full year of meteorological data was obtained, including data on wind, precipitation and other key meteorological variables that the model uses to calculate air pollution dispersion. Model output is PM2.5 level increases caused by power plants in each point over a 12km x 12km grid that covers Eastern and Central China. The modeling grid for each modeled source is 2,580km x 3,480km, using 12km grid spacing⁷. This data was combined with high-resolution population data, matching the 2010 official census data, to estimate the number of people exposed to the pollution in each grid location, giving the total exposure caused by the power plants.

The deaths caused by PM2.5 exposure were assessed using health risk models developed for the World Health Organization Global Burden of Disease study⁸, the most up-to-date and authoritative assessment of the health impacts of PM2.5 globally, including in China. For other health impacts, the most applicable epidemiological results and official or academic data on the incidence and prevalence of different health problems was used.

Emissions from the coal-fired power plants in 2011 were estimated based on average emission levels calculated from Chinese official statistics and power company CSR reports, as well as China Electricity Council plant-by-plant data on capacity, operating hours and thermal efficiency of power plants, and Ministry of Environmental Protection (MEP) data on installed pollution control equipment. Greenpeace compiled data regarding the location of the 2,000+ power plants.

There are several points of uncertainty that could have potentially affected these results. Unlike many other governments, the Chinese government does not yet publish air pollution emission data for individual power plants, so the national and company level emission data has to be attributed to individual power plants using all available plant-

5 <http://www.src.com/calpuff/calpuff1.htm>

6 Zhou et al 2006: The influence of geographic location on population exposure to emissions from power plants throughout China. *Environment International* 32 (2006) 365 – 373.
<http://www.sciencedirect.com/science/article/pii/S016041200500200X>

7 With the exception of sources close to the boundaries of the modeling domain.

8 Lim SS et al 2012: A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990—2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet* 380:2224-2260.
[http://dx.doi.org/10.1016/S0140-6736\(12\)61766-8](http://dx.doi.org/10.1016/S0140-6736(12)61766-8)

level data. The atmospheric simulations carried out by the current version of the CALPUFF model have been found to correspond to observations fairly well, but due to the complexity of atmospheric processes there is always a degree of uncertainty involved. The statistical relationships between PM_{2.5} and risk of death from different diseases and illnesses are scientifically well established, but all estimates have a range of uncertainty associated to them. Nonetheless, this uncertainty does not significantly affect the models, and overall we at Greenpeace believe the modeling results give an unprecedentedly robust and detailed picture of the role of coal-fired power plants in these three provinces and their air pollution issues, and the magnitude of the health impacts caused by power generation from coal in Shandong, Shanxi and Inner Mongolia.

Appendix 2: Coal consumption and GDP in Shandong, Shanxi and Inner Mongolia

By a long way, coal-fired power generation emits more SO₂ and NO_x – two of the key sources of PM_{2.5} in the atmosphere – than any other economic sector. Coal-fired power plants were the source of 50% of industrial SO₂ emissions, 70% of NO_x emissions and 20% of soot emissions in 2011.⁹ Gaseous SO₂ and NO_x emissions are transformed in the atmosphere into sulphate and nitrate particles, two key constituents of PM_{2.5}. This is despite the significant progress made in installing new emission controls.

The rapid growth of coal-burning in Shandong, Shanxi and Inner Mongolia is believed to be one of the key causes for air pollution problem in these three provinces. The total coal consumption of Shandong, Shanxi and Inner Mongolia jumped by 32.7% from 2006 to 2011¹⁰. Rapid growth in coal consumption is undermining any benefits from improved pollution controls, making the air pollution challenge impossible to tackle without bringing total coal consumption under control.

Shandong, Shanxi and Inner Mongolia burned 31% of total coal use in China, and approximately the same amount of coal consumed by the U.S., however combined GDP of these three provinces was only about 15% of China's national total¹¹. Coal consumption

9 <China Environment Statistical Yearbook 2012>

10 <China Energy Statistical Yearbook 2012>

11 National Statistics Bureau, Shandong Statistics Bureau, Shanxi Statistics Bureau, Inner Mongolia Statistics Bureau

per unit GDP production in Inner Mongolia and Shanxi are 30,000 tons and 24,000 tons, figures that far exceed the national average of 9,000 tons¹².

Figure : National coal consumption in China in 2011.

Figure : National GDP production in China in 2011.

Figure : Coal consumption per unit GDP production in Shandong, Shanxi and Inner Mongolia, 2011.

12 National Statistics Bureau, Shandong Statistics Bureau, Shanxi Statistics Bureau, Inner Mongolia Statistics Bureau